

Ground Coupled Heat Pumps

Lambert P. Vogel
Energy Extension Specialist

Harvey Himing
Extension Agricultural Engineer

Many homeowners are searching ways to reduce the cost of heating their homes. Certain conservation methods, such as added insulation, window improvement, application of air and moisture barriers, and heating system improvements have been used quite successfully, but there are homes where these techniques have limited returns. For many of these homes, the only feasible alternative is to install a heating system with an extremely high efficiency.

One heating system that qualifies is called a ground coupled heat pump. The efficiency for these units is stated as coefficient of performance (COP). In some systems, the COP can approach 3.0. This means that the heat pump system moves three times the amount of energy into the home as the electrical energy supplied to the system. The heat pump system would effectively have an efficiency of 300 percent. This is a substantial increase over the high efficiency condensing furnaces that have an efficiency of 95 percent. However, as usual, the increase in efficiency is not without cost, both in terms of money and sophistication.

This heating system has the advantage that it can also be used for cooling. Heat pump systems have been used for many years, using atmospheric air as the source of heat. In an extreme climate like North Dakota's, the air-to-air heat pump's annual COP averages out at about 1.25. This is not much of an advantage considering the cost and complexity of the system.

The ground coupled heat pump receives its heat from the soil. The soil temperature at depth of 5 to 6 feet is quite high - 42° to 45°F and fairly constant. This makes the ground coupled heat pump's coefficient much higher than the air-to-air units.

The ground coupled system is somewhat more costly and also more complex. The piping for collecting the heat can be installed either horizontally or vertically (see Figure 1 and 2). When installed horizontally, trenches are dug and pipe of correct diameter installed. The compaction of soil around the pipe is critical and extreme care must be taken to insure that the soil is properly packed around the pipe.

The length of buried piping required for the system can be impractical unless the lot the home sits on is quite large. Table 1 shows the approximate lengths and pipe sizes needed in North Dakota. For situations where this area is not available, the pipe may be installed in vertical bore holes. The vertical pipes are hooked in parallel to make the flow loops essentially equal (see Figure 3).

Table 1. Approximate lengths of trench and pipes depending on vertical spacing per ton of refrigeration (12,000 BTU's/Hr) for horizontal loops.*

	1 pipe at 5' depth	2 pipes at 3',5' depths	4 pipes at 2',3',4',5' depths
1½" SCH 40 Polybutylene	420 (420)	252 (504)*	176 (704)
¾" Poly- butylene	483 (483)	289 (577)	201 (806)

*Note: 252 = trench length, (504) = pipe length

Note: The actual trench and pipe lengths per ton may differ depending on soil conditions. Pipe lengths will have to be determined for each specific location.

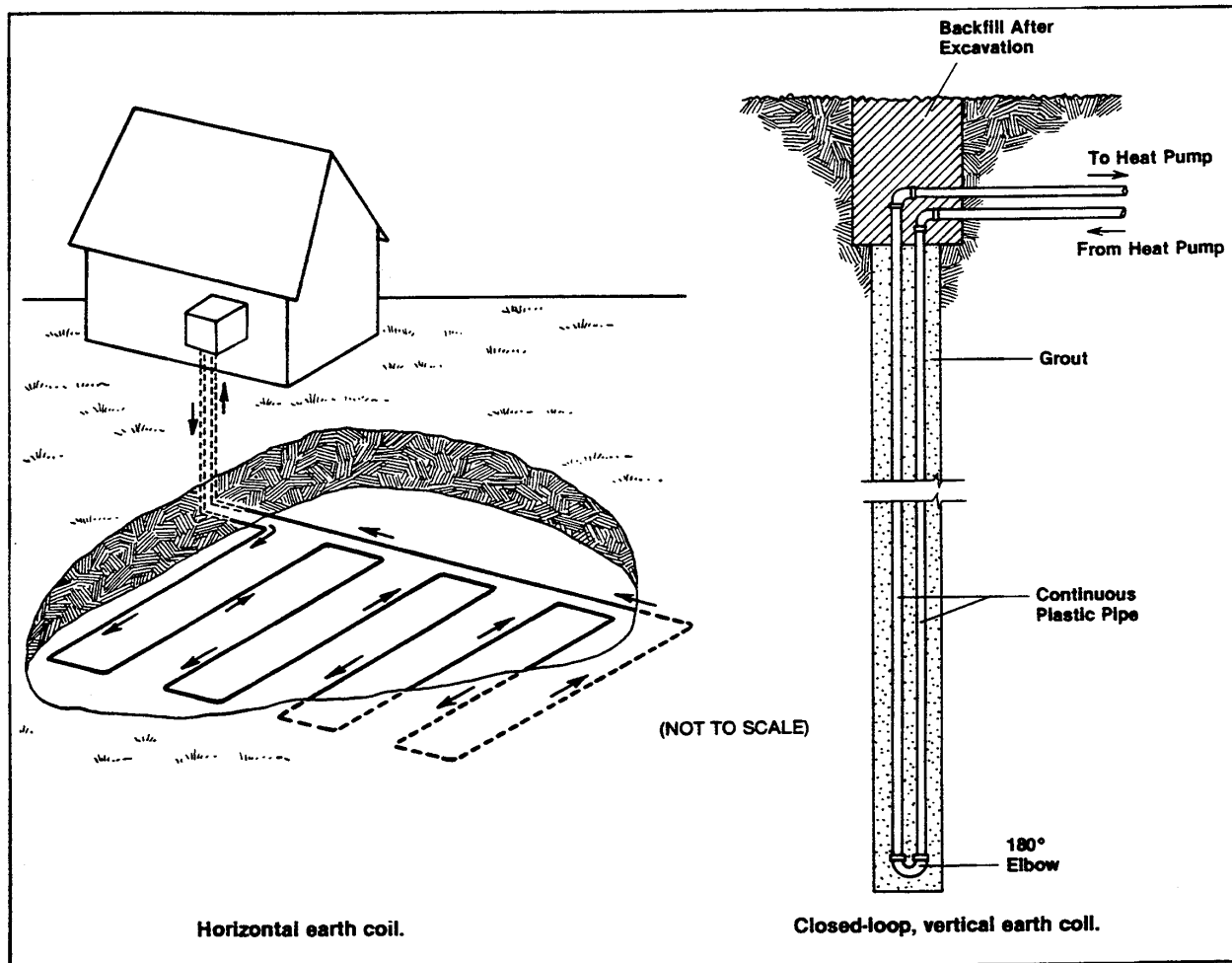


Figure 1

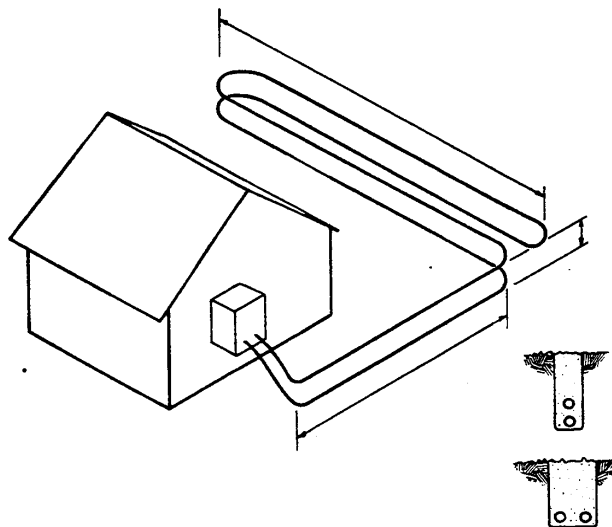


Figure 2. Horizontal earth loop double pipe series.

Recommended piping for the system is either polybutylene or polyethylene with polybutylene being the preferred material.

In North Dakota, a vertical bore hole of from 190 to 210 feet with a 1 inch diameter polybutylene pipe loop installed is required to produce 12,000 BTU/hr. Twelve thousand BTU/hr is referred to as a ton of refrigeration.

Again, backfilling and soil compaction are critical to insure good thermal contact between the polybutylene pipe and soil.

The fluid used in the loops is a brine solution of calcium chloride or sodium chloride and water or a glycol solution. A 20 percent solution by weight of calcium chloride gives freeze protection down to 0°F.

The buried pipe is hooked to a manifold of larger diameter pipe and run into the heating equipment

room in the house. The entry and discharge piping is fitted with appropriate valves, temperature and pressure gauges and flow meters to allow a certain amount of monitoring of the system (see Figure 4). The earth coupled heat pump contains an air handler and is designed to be connected to the home's heating duct system. Since the heated air temperature is somewhat lower than a fossil fueled furnace, the duct sizes will need to be larger to allow greater airflow through the system without increasing noise.

It is possible to use the earth coupled heat pump with a hot water system; however, the heating units for a conventional hot water system will have to be replaced with larger heat exchangers.

The heating requirements for a home can be estimated using standard heat loss calculations, the Agnet House Program, or averaging fuel consumption over the past several years and using the results to make estimates. The heat pump is sized to the design heat load for the home. Electric resistance strip heaters capable of heating the home are incorporated into the air handling system in the event the heat pump becomes inoperative for an extended period of time.

Example: If the design heating load for a particular house is determined to be 36,000 BTU's/hr, a 3-ton heat pump system will be needed. The system will require three 210-foot vertical bore holes. The cost of three bore holes, piping, pump, accessories,

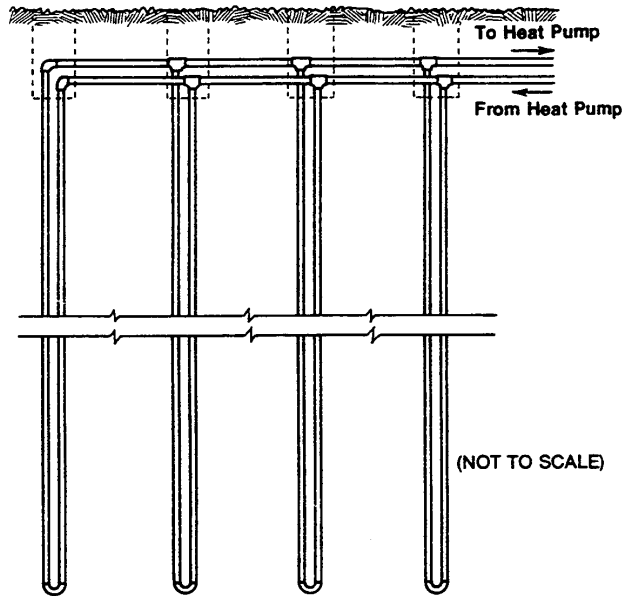


Figure 3. Parallel, closed-loop, vertical earth coil.

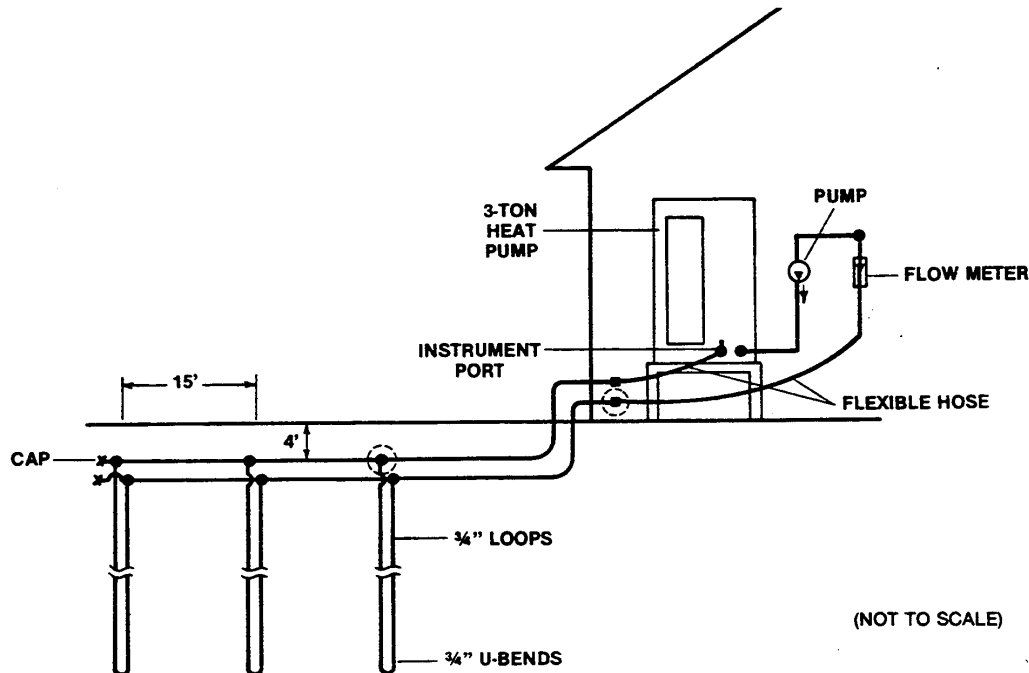


Figure 4. A schematic diagram of an earth coupled heat pump using vertical loops.

and anti-freeze solution ready to hook to the water source heat pump is estimated at \$3,200. The water source heat pump installed is estimated at \$3,800 for a total of \$7,000 (1986 costs).

The duct work for the heating system is approximately \$1.25/sq. ft. of house area. The ducting system would also be required for a conventional furnace.

Using these numbers, your home's yearly energy requirements and estimates of cost for the heating

and air conditioning systems, you can select the most economical system that suits the requirements.

REFERENCES

1. Using the Earth to Heat and Cool Homes. DOE/CE/15095-6. December 1983.
2. Design/Data Manual for Closed-Loop Ground Coupled Heat Pump System. J.E. Bose, J.D. Parker, F.C. McQuiston. Oklahoma State University, 1985. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc.